BC Environment

Overview — Lower Columbia River

Water Quality
GUIDELINES

Water Quality Assessment and Objectives

Columbia River from Birchbank to the International Boundary

MINISTRY OF ENVIRONMENT, LANDS AND PARKS

Water Quality Assessment and Objectives for the Lower Columbia River: Birchbank to the International Border

Overview Report

Prepared pursuant to Section 2(e) of the
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SUMMARY

THIS DOCUMENT is one in a series that describes ambient water quality objectives for British Columbia. It has two parts: the following overview and a technical appendix that was prepared by a consultant as a separate document and published by Environment Canada in 1997. The overview provides general information about water quality in the lower Columbia River between Birchbank and the international boundary, and provides explanations as to differences in water quality objectives in this document compared to the technical appendix. The technical appendix presents the details of the water quality assessment for this area, and forms the basis of the recommendations and most of the objectives that are presented in the overview.

The overview is intended for both technical readers and for readers who may not be familiar with the process of setting water quality objectives. Tables listing water quality objectives and monitoring recommendations are included for those readers requiring data about these water bodies. A separate report has been published which describes the water quality assessment and objectives for the lower Columbia River from the Hugh Keenleyside Dam to Birchbank.

The Columbia River is an important trans-boundary river system that generates a host of benefits to people in Canada and the United States. In addition to in-stream water uses (i.e., fish and aquatic life), the Columbia River provides an important source of raw water for municipal water supplies, irrigation, livestock watering, and industrial water uses. The Columbia River and its tributaries have also been impounded extensively to support hydroelectric power production, water storage, and flood control. Recreation and aesthetics represent important uses of the aquatic environment that generate both social and economic benefits to area residents.

Concerns related to water quality conditions in the Columbia River are primarily related to discharges of industrial and municipal wastes. Discharges of heavy metals from the Cominco lead-zinc

smelter in Trail and chlorinated substances from the Celgar Pulp Company pulpmill in Castlegar have represented the main sources of contaminants. However, discharges of treated municipal sewage from the City of Trail (primary) and the City of Castelgar (secondary) and various non-point sources also contribute to contaminant loading to the lower Columbia River. Elevated levels of dissolved gases and fluctuating water levels are also significant concerns in this system, being generated at dams on the system.

This report describes water quality objectives for the lower Columbia River from Birchbank to the international boundary. These water quality objectives specify the characteristics of water, sediment, and fish muscle tissues necessary to protect aquatic life, wildlife, livestock watering, irrigation, recreation and drinking water supplies in this portion of the river.

PREFACE

Purpose of Water Quality Objectives

Water quality objectives are tools that support effective management of water resources. They describe conditions that water resource managers have agreed should be met in order to protect the most sensitive designated uses of fresh, estuarine, and coastal marine waters. They are used in conjunction with other management tools, such as effluent regulations and "best available or best practicable technology" (BAT/BPT), to achieve high standards of water quality.

Water quality objectives have been and are currently being jointly prepared by Environment Canada and the B.C. Ministry of Environment, Lands, and Parks, as part of their respective mandates for responsible water resource management. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the future.

How Objectives are Determined

Water quality objectives are numerical concentrations or narrative statements that have been established to support and protect the most sensitive designated use of water at a specified site. In British Columbia, the designated uses of water include the following:

- Raw drinking water, public water supply, and food processing;
- Fish, other aquatic life, and wildlife;
- Agriculture (livestock watering and irrigation);
- Recreation and aesthetics; and,
- Industrial water supplies.

The water quality objectives also consider local water quality conditions, water uses, water movement, waste discharges, and other factors.

Water quality objectives are based on water quality guidelines. The water quality guidelines are developed by BC Environment, or in conjunction with the Canadian Council of Ministers of the Environment

(CCME). The guidelines are numerical concentrations or narrative statements for chemical, physical, radiological, and biological characteristics of water, biota (plant and animal life) or sediment that are recommended to support and maintain designated water uses.

The water quality objectives are based on the best scientific information available at the time that they are developed. When insufficient information exists, provisional water quality objectives may be applied until the data required to develop permanent water quality objectives are available. Provisional objectives are used like permanent objectives, but are deliberately conservative. To facilitate the establishment of permanent objectives, a monitoring or study program is usually recommended to fill any data gaps that have been identified. The objective for each variable may be based on the protection of a different water use, depending on which uses are most sensitive to the physical, chemical, or biological characteristics affecting that waterbody.

How Objectives are Used

WATER QUALITY OBJECTIVES have legal standing through regulations established under various provincial statutes (e.g., Forest Practices Code of British Columbia Act, Water Act), but there are also situations where the objectives have no legal standing and therefore cannot be directly enforced. Water quality management in B.C. is achieved through permits issued for effluent discharges with controls placed on, and enforcement actions for, volumes and concentrations of contaminants discharged. The limits set are based upon best available technology for treatment, but more importantly, the assimilative capacity of receiving waters.

Water quality objectives provide environmental quality "goal posts" and policy direction for resource managers and industry for the protection of water uses in specific water bodies. Furthermore, objectives provide a reference:

- for the evaluation of water quality;
- a standard for assessing the Ministry's performance in protecting water uses,

- for issuing of discharge permits,
- for water withdrawal licenses, approvals and orders,
- for the preparation of Liquid Waste Management Plans and Pollution Prevention Plans, and
- for the management of fisheries and the province's land base,
- against which the state of water quality in a particular water body can be checked, and
- to help determine whether more detailed water quality studies should be initiated,

Objectives and Monitoring

Water quality objectives are established to protect all water uses that may take place in a water body. Monitoring is undertaken to determine compliance with the stated water quality objectives and whether the designated water uses are being protected. Monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may be challenging to meet. It is assumed that if all designated water uses are protected at the critical time, then they will also be protected at other times when the threat is less. The monitoring usually takes place during a five-week period, which allows the specialists to measure the worst, as well as the average condition in the water. For some water bodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (i.e., mean value, maximum value).

INTRODUCTION

The Columbia River drains an area of 669 500 km^2 of British Columbia, Washington, Oregon, Idaho, and Montana, making it the dominant river system in the Pacific Northwest. The Columbia River is characterized by a proliferation of impoundments, both in Canada and the United States. From its headwaters at Columbia Lake on the west slope of the Rocky Mountains near Canal Flats, the Columbia River flows some 760 km to its confluence with the Pend d'Oreille River at the international border. Three major dams have been constructed on the Canadian portion of the Columbia River main stem, Mica Dam that created Kinbasket Lake, Revelstoke Dam that formed Revelstoke Lake and Hugh Keenleyside Dam which increased the size of the Arrow Lakes. Major tributaries to the Columbia River include the Kootenay and Pend d'Oreille rivers; several dams regulate the flows in both of these. These two tributaries account for 60% of the mean annual flow of the Columbia River at the international boundary.

The Ministry of Environment, Lands and Parks established water quality objectives in 1992 for the reach of the Columbia River from the Hugh Keenleyside Dam to the Birchbank. This report deals with the Columbia River from Birchbank to the international border. The purpose of this report is to develop water quality objectives for the downstream portion of the lower Columbia River, which encompasses a distance of some 32.5 km.

THE COLUMBIA RIVER FROM BIRCHBANK TO THE INTERNATIONAL BOUNDARY-PROFILE

Hydrology

Streamflow in the lower Columbia River has been regulated through the construction of a series of dams on the Columbia, Kootenay, and Pend d'Oreille rivers. The operation of these facilities, to a large extent, is dictated by the terms of the Columbia River Treaty (1962) and the Non-Treaty Storage Agreement. As these facilities are operated to control flooding and/or to generate electricity, contemporary hydrological conditions do not reflect a natural streamflow regime. Under the regulated streamflow regime, high flows usually occur between December and mid-February. Low flows occur during two periods of the year: March and April; and, September through November. At Birchbank, minimum mean monthly flows are predicted to drop below 630 m^3/s only 0.2% of the time (i.e., one-month in 40).

Water Uses

Consumptive water uses in this reach of the Columbia River include withdrawals of cooling and process water for the Cominco Ltd. lead-zinc smelter at Trail, raw water for municipal water supplies at Trail and Warfield, and limited withdrawals for irrigation. Non-consumptive water uses include hydroelectric power generation (i.e. in upstream areas and on major tributaries), in-stream uses for fish and aquatic life, recreation and aesthetics. Fisheries values in the lower Columbia River are considered to be high, with 24 species using the river during portions of their life histories. Included in this total are several important sportfish species, including rainbow trout, walleye, mountain whitefish, and bull trout. White sturgeon and burbot are two endangered species in this portion of the Columbia River.

The free-flowing portion of the Columbia River is becoming increasingly important for recreational water uses, including kayaking, canoeing, rafting, and powerboat cruising. The navigational locks at the Hugh Keenleyside Dam provide boaters with an opportunity to travel some

500 km between Revelstoke and the Grand Coulee Dam. Recreational water uses are also expanding in the United States portion of the basin, especially within the Coulee Dam National Recreation Area. Sportfishing is a primary recreational pursuit in this area.

Wastewater Discharges

There are a number of wastewater discharges that contribute contaminants to the lower Columbia River. The most significant discharges are from the Cominco Ltd. lead-zinc smelter at Trail and the Celgar Pulp Company pulpmill at Castlegar. Historically, Cominco has discharged significant quantities of heavy metals (including arsenic, cadmium, copper, chromium, lead, mercury, and zinc), while Celgar has discharged organic substances (including dioxins and furans, chlorophenols, resin acids, and fatty acids) into the river, both through wastewater discharges and uncontrolled spills. However, major upgrades have been completed at both of these facilities, resulting in significant improvements in effluent quality. Sewage treatment plants located near Castlegar and Trail release secondary and primary treated sewage, respectively, into the river.

Non-point sources of contaminants have not been fully evaluated in the lower Columbia River basin. However, limited data indicate significant loading of arsenic, cadmium and zinc is originating from old landfills in Stoney Creek basin (which is located near the Cominco Ltd. property). There is also some evidence to suggest that stormwater discharges from the Trail area are contributing contaminants to the river. Agricultural and forestry land uses are considered to be minor sources of contaminants to the lower Columbia River.

Water Quality Assessment and Objectives

Water Quality Assessment

To prepare water quality objectives, information on water quality, sediment quality, and tissue contaminant levels from several locations was examined to assess water quality conditions in the lower Columbia River. The results of this assessment indicate that conditions are fairly good near Birchbank. Monitoring between 1996 and 1999 has shown the concentrations of trace metals, suspended solids, microbial indicators, and nutrients typically fell at or below the water quality guidelines for the protection of aquatic life. However, total gas pressure usually exceeded the levels needed to protect fish and other aquatic organisms.

Water quality was not as good downstream from Trail, with elevated levels of cadmium, copper, lead, and zinc observed downstream from the lead-zinc smelter. Elevated levels of certain microbial indicators were also observed at this site. Water quality appears to improve somewhat between Trail and Waneta. However, the levels of cadmium, copper, chromium and zinc still represent potential hazards to aquatic organisms at Waneta.

Historic wastewater discharges have resulted in contamination of bed sediments in several locations within the study area. Elevated levels of various trace metals, including cadmium, copper, lead, mercury, and zinc have been observed in Columbia River sediments downstream of the Cominco Ltd. lead-zinc smelter. Both slag from this facility and bed sediments from a downstream location (Beaver Creek) have also been shown to be acutely toxic to aquatic organisms. Detectable levels of resin acids, fatty acids, dioxins, and furans have also been observed at various locations; however, these substances are not considered to represent significant hazards to aquatic organisms at the concentrations measured.

Fish from the lower Columbia River have historically contained relatively high levels of certain trace metals and organic substances. Specifically, the concentrations of lead, mercury, and dioxins and furans in muscle and liver tissues from several fish species exceeded the levels that are recommended

for the protection of human health and/or fish-eating wildlife. Elevated levels of trace metals and organic substances have also been observed in aquatic plants and/or benthic invertebrates. However, the most recently collected data indicate that the levels of these contaminants have declined markedly over the past few years, and all consumption advisories have subsequently been lifted.

Water Quality Objectives

The designated water uses that need to be protected in the lower Columbia River from Birchbank to the international boundary include raw water for drinking water supplies that receive partial treatment and disinfection, freshwater aquatic life, wildlife, recreation and aesthetics, irrigation, livestock watering and industrial water supplies. In water, the priority substances with respect to the protection of these uses include pH, suspended solids, total gas pressure, microbial indicators, ammonia, and trace metals. In sediments and fish, the priority substances include trace metals, as well as dioxins and furans. Resin and fatty acids may be a concern in sediments; however, there are no guidelines available against which to judge.

An objective has been added for each of dissolved oxygen and ammonia concentrations in the water column. The values listed for the water column for microbiological indicators, zinc and cadmium and in tissues and sediments for dioxins and furans have been modified from those recommended in the technical appendix. The reasons for these decisions are as follows:

- Microbiological Indicators: the proposed levels of 10/100mL, 10/100 mL, and 3/100 mL for fecal coliforms, *Escherichia coli*, and *Enterococcus*, respectively, have been raised to 100, 100, and 25, respectively. This is necessary since the water requires at least partial treatment prior to human consumption because of turbidity levels, while also needing to provide consistent objectives with those both upstream, and downstream in Washington State.
- Dissolved Oxygen: primary and secondary-treated sewage is discharged to the river. Since there are important fish species in the river, the BC Environment dissolved oxygen guidelines are applied on a site-specific basis, taking general periods when fish eggs will be

buried (November to April) into account. The oxygen percent saturation level of 80% is meant to reflect the influence that temperature can have on available oxygen concentrations.

- Ammonia: the consultant had recommended the 30-day mean ammonia concentrations. The BC guidelines also have instantaneous maximum allowed concentrations, which we have added as site-specific objectives.
- Dioxins and furans: the level proposed by the consultant for sediments is based on a draft BC guideline which has been used in the Fraser River, and for consistency will be used in the lower Columbia River. The level has been met. CCME have recently released draft numbers for dioxins and furans in sediments and fish, but these will not be used for the Columbia. Interestingly, the sediment objective we propose for the Columbia River is more restrictive than the draft CCME number. For fish, the draft BC guideline value which is to protect the organism health of 50 pg/g (normalized for lipid content) is slightly more restrictive than that proposed by the consultant to protect wildlife, but is slightly more lenient than the draft CCME number. None of the levels are presently met and the objective is long-term. We expect that the objective will be met in the near future since the Celgar mill has reduced loading in the early 1990's.
- Cadmium: the proposed level by the consultant was that the 30-day mean concentration should not exceed 0.03 μg/L. This will remain as the long-term objective for the lower Columbia, while the short-term objective will be a 30-day mean concentration of 0.05 μg/L. The rationale for this decision is as follows. The data collected under the Federal/Provincial monitoring program at Waneta and Birchbank indicate that the sampling and analytical methods are very reliable when measuring concentrations of extractable cadmium at 0.06 to 0.09 μg/L, but less reliable at 0.01 to 0.03 μg/L. The short-term objective will allow the application of these site-specific precision data in the development of the objective. The cadmium data collected in recent years indicate that mean cadmium concentrations are decreasing, due to effluent treatment improvements and the capture of runoff and seepage entering Stoney Creek, and that the short-term objective should likely be met. Turbidity levels are low throughout the river, with turbidity values generally all less than 5 NTU, and about 85% to 90% of all values less than 1 NTU. These

low values mean that metal concentrations measured as total, extractable, or dissolved will probably give similar results.

- Zinc: the proposed level of 7 µg/L was based upon a draft CCME guideline prepared by BC Environment. In developing the approved BC guideline, we proposed two concentrations (not normal for CCME), a maximum concentration and a 30-day mean concentration. A problem with using only the maximum 7 µg/L value is that zinc is an essential element, and the 7 µg/L level could result in possible zinc deficiency to aquatic organisms. By using the approved BC maximum and 30-day mean guidelines, the full set of toxicological data could be used and the issue of zinc deficiency can be addressed. The objective for the lower Columbia is that the 30-day mean concentration should not exceed 7.5 µg/L and the maximum concentration should not exceed 33 µg/L.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions that can be met in the future. To limit the scope of the work, Objectives are currently being prepared only for water bodies and for water quality characteristics that may be affected by human activity now and in the foreseeable future.

The water quality objectives for the lower Columbia River from Birchbank to the international boundary are presented in Tables 1, 2 and 3. These objectives are based on the approved and working water quality guidelines for British Columbia, on additional toxicological information and available data on ambient water quality, wastewater discharges, water uses, and streamflow.

The water quality objectives for many of the priority substances identified are currently being met most or all of the time within portions of the lower Columbia River. Where these objectives are not being met presently, they represent targets that should be used to identify priorities for future investigations, management actions, and remedial measures.

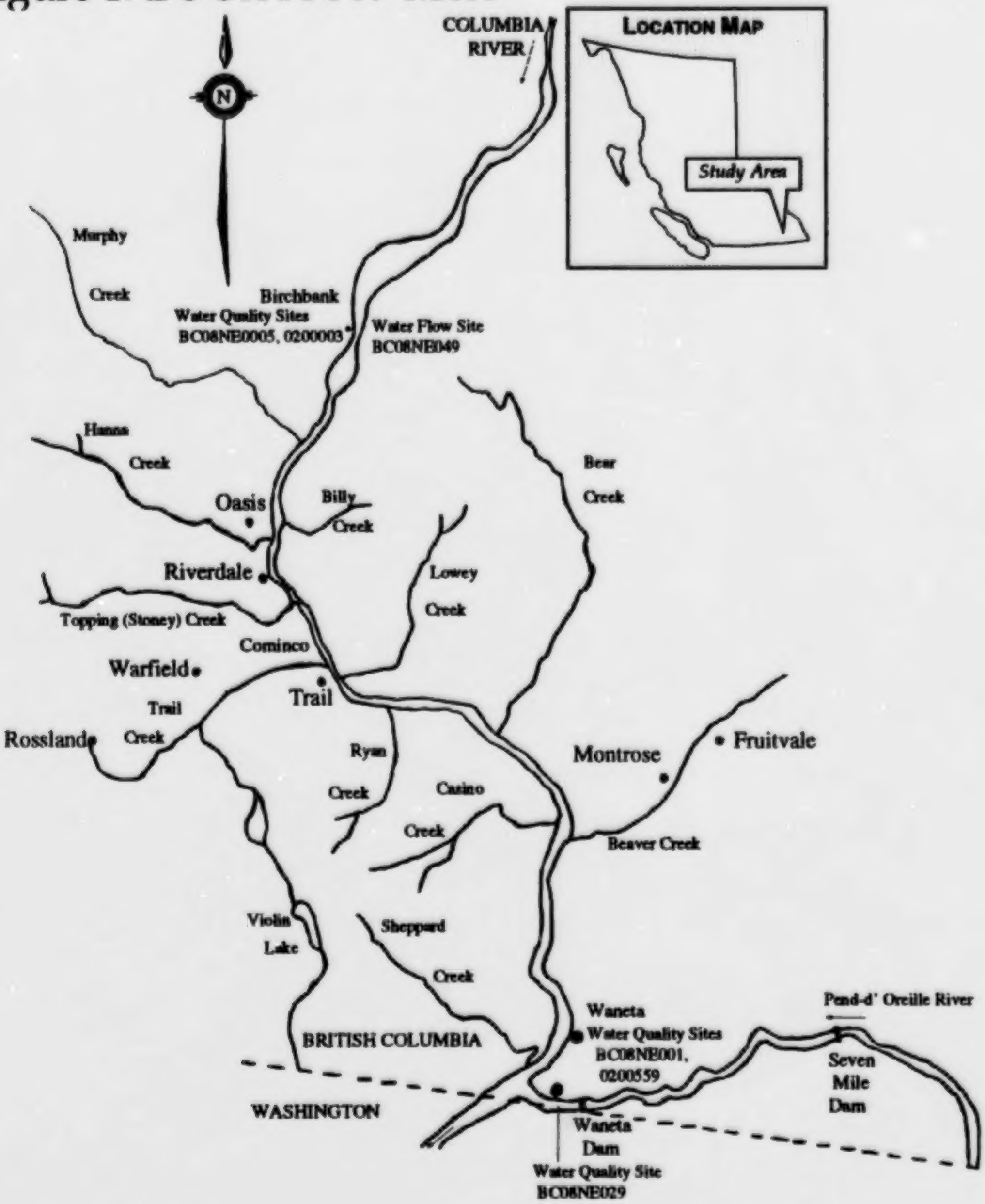
In the past, streamflow in the lower Columbia River has been managed in accordance with the provisions of the Columbia River Treaty and the Non-

Treaty Storage Agreement. As such, water management objectives were primarily focussed on flood control and hydroelectric power generation. In recent years, however, it has been recognized that alterations of the natural hydrological regime now have the largest potential to adversely affect aquatic organisms and their uses (such as recreation and aesthetics). For this reason, it is recommended that the flow regime be managed to protect the structure, productivity, and health of aquatic communities, while respecting the obligations in the Columbia River Treaty (and associated agreements) and societal needs for power generation and flood control.

Monitoring Recommendations

Monitoring programs should be designed and carried out to determine the degree to which the water quality objectives are being met during critical ecological periods. When objectives are exceeded, one or more designated water uses may be threatened. Monitoring ecosystem responses to environmental disturbances provides a direct means of identifying situations where more restrictive effluent standards may be required or where the water quality objectives need to be adjusted to meet water management goals. A recommended monitoring program design for the lower Columbia River is presented in Table 4. The actual monitoring undertaken will depend upon available regional resources and will be co-ordinated with other monitoring programs such as the Columbia River Integrated Environmental Monitoring Program (CRIEMP).

Figure 1: Location Map



WATER QUALITY OBJECTIVES AND MONITORING TABLES

A summary of the water quality objectives is provided in Table 1. The recommended monitoring program for the lower Columbia River is presented in Tables 4. The objectives typically specify ranges of water quality conditions that are likely to protect the designated water uses in a waterbody. As such, the objectives often specify maximum, 90th percentile, or mean or average values that are not to be exceeded. In some cases, minimum values are also specified.

Some readers may be unfamiliar with terms such as: maximum concentrations, 30-day average concentration, 90th percentile, and not applicable (NA). A maximum concentration refers to the value for a specific variable that should never be exceeded. A 30-day average or mean concentration defines the level that should not be exceeded by the average value calculated for five or more samples that are collected at approximately equal intervals during a period of 30 days. The term 90th percentile indicates that 9 out of 10 values should be less than a particular value. Not applicable means that water uses are not threatened for that particular variable.

TABLE 1

WATER QUALITY OBJECTIVES FOR THE COLUMBIA RIVER FROM BIRCHBANK TO THE INTERNATIONAL BOUNDARY

Characteristics	Columbia River From Birchbank to the International Boundary
Designated Water Uses	Drinking water (partial treatment plus disinfection), aquatic life, wildlife, livestock, irrigation, primary-contact recreation
Fecal coliforms (1)	≤100/100 mL (90th percentile)
Enterococci (1)	≤25/100 mL (90th percentile)
Escherichia coli (1)	≤100/100 mL (90th percentile)
Ammonia-N (total)	See Tables 2 and 3
pH	6.5 - 8.5
Dissolved Oxygen	≥5 mg/L instantaneous minimum, 30-day average ≥ 8.0 mg/L or 80% saturation, whichever is higher (May to October), and ≥9 mg/L instantaneous minimum, and 30-day average ≥ 11 mg/L (November to April)
Total Gas Pressure	≤ 110%
Arsenic (total)	5 µg/L mean ≤ 5.7 µg/g (dry-weight) in sediments ≤ 471 µg/g wet-weight in fish muscle tissue
Cadmium (total)	0.03 µg/L long-term mean; 0.05 µg/L short-term mean ≤ 0.6 µg/g (dry-weight) in sediments ≤ 900 µg/g wet-weight in fish muscle tissue
Chromium (total)	1 µg/L mean ≤ 36.4 µg/g (dry-weight) in sediments ≤ 940 µg/g wet-weight in fish muscle tissue
Copper (total)	2 µg/L mean: ≤ 7.2 µg/L maximum ≤ 35.1 µg/g (dry-weight) in sediments
Lead (total)	4.8 µg/L mean; ≤ 37.9 µg/L maximum ≤ 33.4 µg/g (dry-weight) in sediments ≤ 160 µg/g wet-weight in fish muscle tissue
Mercury (total)	≤ 0.16 µg/g (dry-weight) in sediments ≤ 100 µg/g wet-weight in fish muscle tissue
Thallium (total)	≤ 0.8 µg/L mean
Zinc (total)	≤ 7.5 µg/L mean, ≤ 33 µg/L maximum ≤ 120 µg/g (dry-weight) in sediments
Dioxins and Furans (2,3,7,8-T_4CDD TEQ's)	≤0.25 pg. TEQ/g (normalized to 1% organic carbon) sediments ≤50 pg/g (wet-weight) normalized to lipid content of fish muscle or fish eggs (long-term)

Note: Water quality objectives do not apply in initial dilution zones where acutely toxic conditions are not permitted. Water quality objectives do apply to discrete samples of water and sediment from all other parts of the Columbia River from Birchbank to the International Boundary. In practice, the extent of initial dilution zones is defined on a site-specific basis, with due regard to water uses, aquatic life, including migratory fish, and other waste discharges. However, where sufficient site-specific data are not available for defining initial dilution zones, the initial dilution zones will be defined as extending up to 100 metres downstream from a discharge, and occupying no more than 25% of the stream width around the discharge point, from the bed of the stream to the surface. It is also important to note that objectives for fish tissues apply to all parts of the river, including fish in the initial dilution zone.

[1] The average or mean, and the 90th percentiles are calculated from at least five weekly samples in a period of thirty days. For values recorded as less than the detection limit, the detection limit itself should be used in calculating the statistic. The 75th or 90th percentiles can be extrapolated by graphical methods when fewer than ten samples are collected.

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TABLE 2
MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

	Temperature										
pH	0°C	1°C	2°C	3°C	4°C	5°C	6°C	7°C	8°C	9°C	10°C
6.5	27.7	28.3	27.9	27.5	27.2	26.8	26.5	26.2	26	25.7	25.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8	25.5	25.2	25	24.7
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9	24.6	24.4	24.1	23.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9	23.6	23.4	23.1	22.9
6.9	24.6	24.2	23.9	23.6	23.3	23	22.7	22.5	22.2	22	21.8
7	23.2	22.8	22.5	22.2	21.9	21.6	21.4	21.1	20.9	20.7	20.5
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9	19.7	19.5	19.3	19.1
7.2	19.9	19.6	19.3	19	18.8	18.6	18.3	18.1	17.9	17.8	17.6
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.2	16
7.4	16.2	16	15.7	15.5	15.3	15.2	15	14.8	14.7	14.5	14.4
7.5	14.4	14.1	14	13.8	13.6	13.4	13.3	13.1	13	12.9	12.7
7.6	12.6	12.4	12.2	12	11.9	11.7	11.6	11.5	11.4	11.3	11.2
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10	9.92	9.83	9.73	9.65
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57	8.48	8.4	8.32	8.25
7.9	7.82	7.71	7.6	7.51	7.42	7.33	7.25	7.17	7.1	7.04	6.98
8	6.55	6.46	6.37	6.29	6.22	6.14	6.08	6.02	5.96	5.91	5.86
8.1	5.21	5.14	5.07	5.01	4.95	4.9	4.84	4.8	4.75	4.71	4.67
8.2	4.15	4.09	4.04	3.99	3.95	3.9	3.86	3.83	3.8	3.76	3.74
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09	3.06	3.03	3.01	2.99
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47	2.45	2.43	2.41	2.4
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98	1.96	1.95	1.94	1.93
8.6	1.69	1.67	1.65	1.63	1.61	1.6	1.59	1.58	1.57	1.56	1.55
8.7	1.35	1.33	1.32	1.31	1.3	1.29	1.28	1.27	1.26	1.26	1.25
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.83

	Temperature									
pH	11°C	12°C	13°C	14°C	15°C	16°C	17°C	18°C	19°C	20°C
6.5	25.2	25	24.8	24.6	24.5	24.3	24.2	24	23.9	23.8
6.6	24.5	24.3	24.1	23.9	23.8	24.6	23.5	23.3	23.3	23.2
6.7	23.7	23.5	23.3	23.1	23	22.8	22.7	22.6	22.5	22.4
6.8	22.7	22.5	22.3	22.2	22	21.9	21.8	21.7	21.6	21.5
6.9	21.6	21.4	21.3	21.1	21	20.8	20.7	20.6	20.5	20.4
7	20.3	20.2	20	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.9	18.8	18.7	18.5	18.4	18.3	18.2	18.1	18	17.9
7.2	17.4	17.3	17.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.9	15.7	15.6	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	14.2	14.1	14	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.6	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12
7.6	11.1	11	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.57	9.5	9.43	9.37	9.31	9.26	9.22	9.81	9.15	9.12
7.8	8.18	8.12	8.07	8.02	7.97	7.93	7.9	7.87	7.84	7.82
7.9	6.92	6.88	6.83	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8	5.81	5.78	5.74	5.71	5.68	5.66	5.64	5.62	5.61	5.6
8.1	4.64	4.61	4.59	4.56	4.54	4.53	4.51	4.5	4.49	4.49
8.2	3.71	3.69	3.67	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.97	2.96	2.94	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.38	2.37	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.92	1.91	1.91	1.9	1.9	1.9	1.9	1.9	1.91	1.92
8.6	1.55	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.56	1.57
8.7	1.25	1.25	1.25	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.87	0.88	0.891

TABLE 3
AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temperature										
	0°C	1°C	2°C	3°C	4°C	5°C	6°C	7°C	8°C	9°C	10°C
6.5-7.7	2.09	2.05	2.02	2.0	1.98	1.95	1.93	1.9	1.89	1.87	1.86
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.6	1.59
7.9	1.5	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34
8	1.26	1.24	1.23	1.21	1.2	1.18	1.17	1.16	1.15	1.14	1.13
8.1	1	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.73	0.724	0.718
8.3	0.636	0.628	0.62	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.4	0.396	0.381	0.387	0.384	0.38	0.377	0.375	0.372	0.37
8.6	0.324	0.32	0.317	0.313	0.31	0.308	0.305	0.303	0.301	0.3	0.298
8.7	0.26	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.2	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.131	0.131	0.131	0.131	0.131

pH	Temperature									
	11°C	12°C	13°C	14°C	15°C	16°C	17°C	18°C	19°C	20°C
6.5-7.7	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.33	1.32	1.31	1.31	1.3	1.21	1.12	1.04	0.97	0.904
8	1.12	1.11	1.1	1.1	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.7	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.24	0.24	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.16	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 3.
- each measured value is compared to the corresponding individual values in Table 3.

No more than one in five of the measured values can be greater than one-and-a-half times the corresponding objective values in Table 3.

TABLE 2
MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temperature										
	0°C	1°C	2°C	3°C	4°C	5°C	6°C	7°C	8°C	9°C	10°C
6.5	27.7	28.3	27.9	27.5	27.2	26.8	26.5	26.2	26	25.7	25.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8	25.5	25.2	25	24.7
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9	24.6	24.4	24.1	23.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9	23.6	23.4	23.1	22.9
6.9	24.6	24.2	23.9	23.6	23.3	23	22.7	22.5	22.2	22	21.8
7	23.2	22.8	22.5	22.2	21.9	21.6	21.4	21.1	20.9	20.7	20.5
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9	19.7	19.5	19.3	19.1
7.2	19.9	19.6	19.3	19	18.8	18.6	18.3	18.1	17.9	17.8	17.6
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.2	16
7.4	16.2	16	15.7	15.5	15.3	15.2	15	14.8	14.7	14.5	14.4
7.5	14.4	14.1	14	13.8	13.6	13.4	13.3	13.1	13	12.9	12.7
7.6	12.6	12.4	12.2	12	11.9	11.7	11.6	11.5	11.4	11.3	11.2
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10	9.92	9.83	9.73	9.65
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57	8.48	8.4	8.32	8.25
7.9	7.82	7.71	7.6	7.51	7.42	7.33	7.25	7.17	7.1	7.04	6.98
8	6.55	6.46	6.37	6.29	6.22	6.14	6.08	6.02	5.96	5.91	5.86
8.1	5.21	5.14	5.07	5.01	4.95	4.9	4.84	4.8	4.75	4.71	4.67
8.2	4.15	4.09	4.04	3.99	3.95	3.9	3.86	3.83	3.8	3.76	3.74
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09	3.06	3.03	3.01	2.99
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47	2.45	2.43	2.41	2.4
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98	1.96	1.95	1.94	1.93
8.6	1.69	1.67	1.65	1.63	1.61	1.6	1.59	1.58	1.57	1.56	1.55
8.7	1.35	1.33	1.32	1.31	1.3	1.29	1.28	1.27	1.26	1.26	1.25
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.83

pH	Temperature									
	11°C	12°C	13°C	14°C	15°C	16°C	17°C	18°C	19°C	20°C
6.5	25.2	25	24.8	24.6	24.5	24.3	24.2	24	23.9	23.8
6.6	24.5	24.3	24.1	23.9	23.8	24.6	23.5	23.3	23.3	23.2
6.7	23.7	23.5	23.3	23.1	23	22.8	22.7	22.6	22.5	22.4
6.8	22.7	22.5	22.3	22.2	22	21.9	21.8	21.7	21.6	21.5
6.9	21.6	21.4	21.3	21.1	21	20.8	20.7	20.6	20.5	20.4
7	20.3	20.2	20	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.9	18.8	18.7	18.5	18.4	18.3	18.2	18.1	18	17.9
7.2	17.4	17.3	17.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.9	15.7	15.6	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	14.2	14.1	14	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.6	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12
7.6	11.1	11	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.57	9.5	9.43	9.37	9.31	9.26	9.22	9.81	9.15	9.12
7.8	8.18	8.12	8.07	8.02	7.97	7.93	7.9	7.87	7.84	7.82
7.9	6.92	6.88	6.83	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8	5.81	5.78	5.74	5.71	5.68	5.66	5.64	5.62	5.61	5.6
8.1	4.64	4.61	4.59	4.56	4.54	4.53	4.51	4.5	4.49	4.49
8.2	3.71	3.69	3.67	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.97	2.96	2.94	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.38	2.37	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.92	1.91	1.91	1.9	1.9	1.9	1.9	1.9	1.91	1.92
8.6	1.55	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.56	1.57
8.7	1.25	1.25	1.25	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.87	0.88	0.891

TABLE 3
AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

	Temperature										
pH	0°C	1°C	2°C	3°C	4°C	5°C	6°C	7°C	8°C	9°C	10°C
6.5-7.7	2.09	2.05	2.02	2.0	1.98	1.95	1.93	1.9	1.89	1.87	1.86
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.6	1.59
7.9	1.5	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34
8	1.26	1.24	1.23	1.21	1.2	1.18	1.17	1.16	1.15	1.14	1.13
8.1	1	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.73	0.724	0.718
8.3	0.636	0.628	0.62	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.4	0.396	0.381	0.387	0.384	0.38	0.377	0.375	0.372	0.37
8.6	0.324	0.32	0.317	0.313	0.31	0.308	0.305	0.303	0.301	0.3	0.298
8.7	0.26	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.2	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.131	0.131	0.131	0.131	0.131

	Temperature									
pH	11°C	12°C	13°C	14°C	15°C	16°C	17°C	18°C	19°C	20°C
6.5-7.7	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.33	1.32	1.31	1.31	1.3	1.21	1.12	1.04	0.97	0.904
8	1.12	1.11	1.1	1.1	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.7	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.24	0.24	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.16	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 3.
- each measured value is compared to the corresponding individual values in Table 3.

No more than one in five of the measured values can be greater than one-and-a-half times the corresponding objective values in Table 3.

TABLE 4
RECOMMENDED WATER QUALITY MONITORING FOR THE COLUMBIA RIVER FROM BIRCHBANK TO THE INTERNATIONAL BOUNDARY

Site Number	Location	Frequency	Date	Variables
0200003	Columbia River at Birchbank (West Bank)	5 times weekly in 30 days	January, April, September	Temperature, Fecal coliforms, *Enterococci, E. coli*, , turbidity, Dissolved Oxygen, Total Gas Pressure, NH3–N, pH, hardness, turbidity, suspended solids, As, Cd, Cr, Cu, Pb, Tl, Zn
New Site	Columbia River between Birchbank and Stoney Creek	Once Twelve individuals	July	Species, age, sex, condition, gross abnormalities, lipid content, moisture content, As, Cd, Cr, Cu, Pb, Hg, Tl, Zn, PCDDs and PCDFs
New Site	Columbia River between Birchbank and Stoney Creek	Once Five replicates	September	TOC, AVS, particle size, Total and SEM metals (As, Cd, Cr, Cu, Pb, Hg, Tl, Zn) dehydroabietic and total resin acids, PCDDs and PCDFs, fatty acids, acute and short-term chronic toxicity (*Chironomus riparius and Hyalella azteca)*
New Site	Columbia River 100 m downstream from Stoney Creek (Topping Creek) (West Bank)	5 times weekly in 30 days	January, April, September	Temperature, turbidity, pH, Dissolved Oxygen, hardness, As, Cd, Cr, Cu, Pb, Tl, Zn
New Site	Columbia River at Old Trail Bridge on West Bank	5 times weekly in 30 days	January, April, September	Temperature, turbidity, Dissolved Oxygen, NH3–N, pH, hardness, As, Cd, Cr, Cu, Pb, Tl, Zn
New Site	Columbia River 100 m downstream from Kootenay Boundary Regional District STP Outfall	5 times weekly in 30 days	January, April, September	Fecal coliforms, *Enterococci, E. coli*, , NH3–N, turbidity,

New Site	Columbia River between West Trail Bridge and Waneta	Once Twelve individuals	July	Species, age, sex, condition, gross abnormalities, lipid content, moisture content, As, Cd, Cr, Cu, Pb, Hg, Tl, Zn, PCDDs and PCDFs
New Site	Columbia River between West Trail Bridge and Waneta	Once Five replicates	September	TOC, AVS, particle size, Total and SEM metals (As, Cd, Cr, Cu, Pb, Hg, Tl, Zn) dehydroabietic and total resin acids, PCDDs and PCDFs, fatty acids, acute and short-term chronic toxicity (*Chironomus riparius and Hyalella azteca)*
0200559	Columbia River at Waneta on East Bank	5 times weekly in 30 days	January, April, September	Temperature, Fecal coliforms, *Enterococci*, *E. coli*, , turbidity, Dissolved Oxygen, Total Gas Pressure, NH3–N, pH, hardness, turbidity, suspended solids, As, Cd, Cr, Cu, Pb, Tl, Zn